Overseas 64-m-Diameter Antenna Power Configuration

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The construction of the two new 64-m-diameter antennas located at DSS 63 (Madrid) and DSS 43 (Tidbinbilla) required additional power generating equipment at these sites. As the new sites were in close proximity to the existing DSS 61 (Madrid) and DSS 42 (Tidbinbilla), the new equipment was designed to integrate with the existing power generating and distribution systems. This integration will enable the new and existing generators to be combined into a single generating system and provide total site power for both 64-m and 26-m antenna station requirements. Studies are being made to determine the economic and technical advantages of using commercial power. If proved favorable, the equipment presently being installed is designed to provide parallel operation of the generating system with commercially produced power.

The new equipment is equipped with automatic generator starting and stopping features and power demand sensing monitors. The monitors automatically start, synchronize, and connect generators to share load demand equally between running generators as power demand increases. Conversely, if the demand decreases, unnecessary generators are removed from the generating system. This article describes the techniques developed and incorporated in the design of the new generation and distribution equipment and the proposed future development of the power generating systems.

I. Introduction

This progress report describes the engineering development of the power generation and distribution systems for the 64-m-diameter antennas. Interconnection with existing 26-m-diameter antenna power generation and distribution systems and future commercial power source is also described.

II. Existing Power Generation and Distribution Systems at DSS 61 (Madrid) and DSS 42 (Canberra)

At both of the existing sites, power is derived from diesel engine-driven generators which deliver 480 volts, three phase, 60 hertz. Equipment requiring other voltages or frequencies is supplied through transformers or frequency converters which are powered from the 480-volt 60-hertz main power system. Figure 1 is a simplified single line diagram of the system. Figure 2 gives a picture of a typical engine–generator line-up.

The generating equipment is controlled manually by operating personnel on a three-shift work schedule. Starting, stopping, synchronizing, and load control of diesel engine-driven generators for required power loads are under the control of these personnel.

The generating capacity of the system is adequate for the power demands imposed, which are relatively small. Sudden loads imposed by equipment such as air conditioners and relatively large motors could cause transient voltage and frequency fluctuations outside acceptable limits for other electronic equipment. This problem has been solved by providing switching devices which allow electrical separation of the system into two independent power subsystems which are entitled "U" bus for utility loads and "E" bus for more sensitive electronic loads. Completely separate operation of these subsystems prevents fluctuations of "E" bus voltage or frequency due to load changes on the "U" bus.

Although the "U" loads can tolerate momentary voltage and frequency fluctuations to a greater degree than electronic loads, large motors connected to the "U" power distribution subsystem are equipped with reduced voltage starters to prevent sudden application of large power demands.

Some limited testing at DSS 14, with an adequate number of generators connected to interconnected "E" and "U" bus power distribution subsystems, indicates that present day electronic equipment may tolerate fluctuations presently experienced by the "U" bus system. Further research is being conducted to establish the adequacy of a single bus power system. The advantages of a single bus power generation and distribution system in terms of simplicity of design and operation with accompanying equipment cost savings are very desirable but need careful evaluation to ensure that the operation of electronic equipment is not endangered.

III. Requirement for New Generation and Distribution Systems for 64-m Antennas at DSS 63 (Madrid) and DSS 43 (Tidbinbilla)

The new 64-m antennas at both sites require an initial generating capacity of 3000 kilowatts. This power requirement led to an economic choice of a higher generated voltage level of 2400 volts rather than the 480-volt level presently used by existing 26-m antenna power systems, and the use of four generators each rated at 750 kilowatts for each site. Future increase in power requirements will be met by adding similarly rated generators. Figure 3 is a single line diagram for a 64-m antenna power system.

A study was made to establish the best performance capability available from proven, commercially available, diesel-driven generating equipment and compared with up-to-date performance requirements established by the National Communication System as shown in Fig. 4.

The required performance for normal operation of the system with steady, continuous load could easily be met by commercially produced equipment. The transient voltage and frequency fluctuations allowable during application or removal of sudden loads required more careful study. The maximum value of sudden load application or removal was established at 75% of connected generator capacity as discussed in *Section V* of this article. Turbo-charged diesel engines rely on exhaust gas volume to drive the turbo-charger and thereby supplement naturally aspirated air to the diesel engine. Sudden application of load momentarily slows the engine and turbo-charger, which stifles air supply at the precise moment the engine requires it to recover normal speed.

To maintain the required frequency performance, a supplementary combustion air system was fitted to each engine. This consists of a simple compressed air storage tank connected to the engine air inlet manifold through an electrically controlled valve. The valve opens only when a sudden load application occurs, and the resulting improvement in diesel engine recovery is well within performance requirements as indicated in Fig. 4.

As mentioned in *Section II* of this article, the need for separate "E" and "U" systems at the 26-m antenna sites is doubtful and is being studied. The greater generating capacity and superior performance of the generators equipped with supplementary air systems at the 64-m antenna sites led to the design of a single operational "O" system.

The design includes a second bus for the testing of generators designated "T." The "T" bus will allow generator testing without interference with normal operation of the power system, will allow for personnel training and may be used for future power to the high power transmitter. If, for some presently unforeseen reason, the single operational bus system proves to be unsatisfactory, the system can be easily converted to the conventional "E" and "U" two-bus system.

Recently available control components using solid-state components have been used to improve the performance and relieve the sometimes tedious manual control of generator equipment at the 26-m antenna stations. Improved voltage regulators with automatic kilovar equalizing controls and automatic electronic governor controls with kilowatt load equalizing features are in this category and have proven their usefulness and reliability at these stations. A new automatic synchronizer with double-check features and an automatic generator start–stop device based on demand load have been produced commercially. These devices have been used in the generator control system to provide fully automated control of the new 64-m antenna generating systems. After initial settings have been made, the control operations usually performed by shift personnel will be automatically performed by the control devices. During initial operation, to allow familiarization by personnel and as an insurance against malfunction, the equipment can be switched to completely conventional manual control.

IV. Integration of New and Existing Power Generation and Distribution Systems

The intention is to operate the existing 26-m and 64-m antenna power generation and distribution systems as a single integrated power system. This will not preclude the operation of the systems individually or the preselection of either automatic or manual control mode. Mode control is by simple control switch operations.

The integration of the two antenna power systems will be in two phases. The first phase of the integration will be accomplished on completion of the initial installation of the 64-m antenna equipment. Interconnection of the power systems will be through power switching circuit breakers when desired. The integrated power system diagram is shown in Fig. 5. Synchronizing equipment provided allows connecting generators to generator bus systems but is not provided across tie circuit breakers during this phase of the systems integration. This means that shut down of one of the systems is necessary to make the tie between the power systems.

During the first phase of integrated operation of the two power systems, the 26-m antenna power generators remain under control of operating personnel. The 64-m antenna power generators are "slaved" to the 26-m antenna power generation system and will share that portion of load on the total system not being provided by the 26-m antenna generating system. Voltage and frequency control of the integrated power system will be completely manual by operating personnel at the 26-m antenna power generation control console.

Phase 2 of the power systems integration will be implemented in the near future. It will provide for interconnecting the 64-m and 26-m antenna power system with both systems energized, without momentary shut down of either system. This will be accomplished by provision of synchronizing equipment across the interconnecting tie circuit breaker.

Another feature planned under this phase of the power systems integration is the addition of equipment to allow automatic start–stop control, automatic load sharing, and kilovar sharing to the existing 26-m antenna power generators. This will completely integrate the 26-m/64-m antenna power system with fully automatic control capabilities.

V. Integration of Commercial Power With the Generator Power Systems

The capital expenditure, amortization period, cost per kilowatt hour, and costs for maximum power demand for commercial power are presently being compared with fuel savings, maintenance and repair cost savings for reduced operating time and operating personnel costs associated with the generating plant operation. Comparison will determine the possible economic advantages of purchasing commercial power at the sites.

If the results of this study indicate that commercial power should be used, there will be the operational advantages of using this power source as an alternative backup in case of critical failure of the generating system.

The equipment presently provided will accommodate an incoming commercial power source, and control devices included will permit operation of the 64-m antenna generators in parallel with the commercial power source.

In this mode of operation, simple controls will allow a preset percentage of the total system kilowatt load to be assumed by the connected generators and the major portion of the system kilowatts to be derived from the commercial power source. Other controls allow setting of kilovars drawn from the commercial power source. Normal setting of this control will be to minimize kilovars from the commercial source, so that generators will supply most of the kilovar load demand. It will be noted that kilowatt and kilovar loads drawn from the commercial source and the generators source are functionally opposite, the least expensive kilowatts being derived from the commercial and the least expensive kilovars being derived from the generators. Kilovar loading of generators has negligible effect on diesel engine fuel consumption.

For critical mission operation the most reliable operation of the power system will be with a sufficient number of generators connected to satisfy the total load of the system and the commercial power source connected in parallel with the generators. This mode of operation will provide 100% power source capability in excess of requirements. The load kilowatts derived from the engine–generators will be the minimum consistent with stable governor and clean engine performance, nominally 25% of generator rating. Total kilovar load of the power system will be shared equally by the generators.

The commercial source will provide 75% of the power system kilowatt loading and none of the system kilovars. Worst case voltage and frequency fluctuations would occur in case of loss of the utility power source. There would be no increase in generator kilovar loading but kilowatt loading on the generator would rise from 25 to 100%. As indicated in Fig. 4, the engine–generators will maintain voltage and frequency well within specified requirement under these conditions.

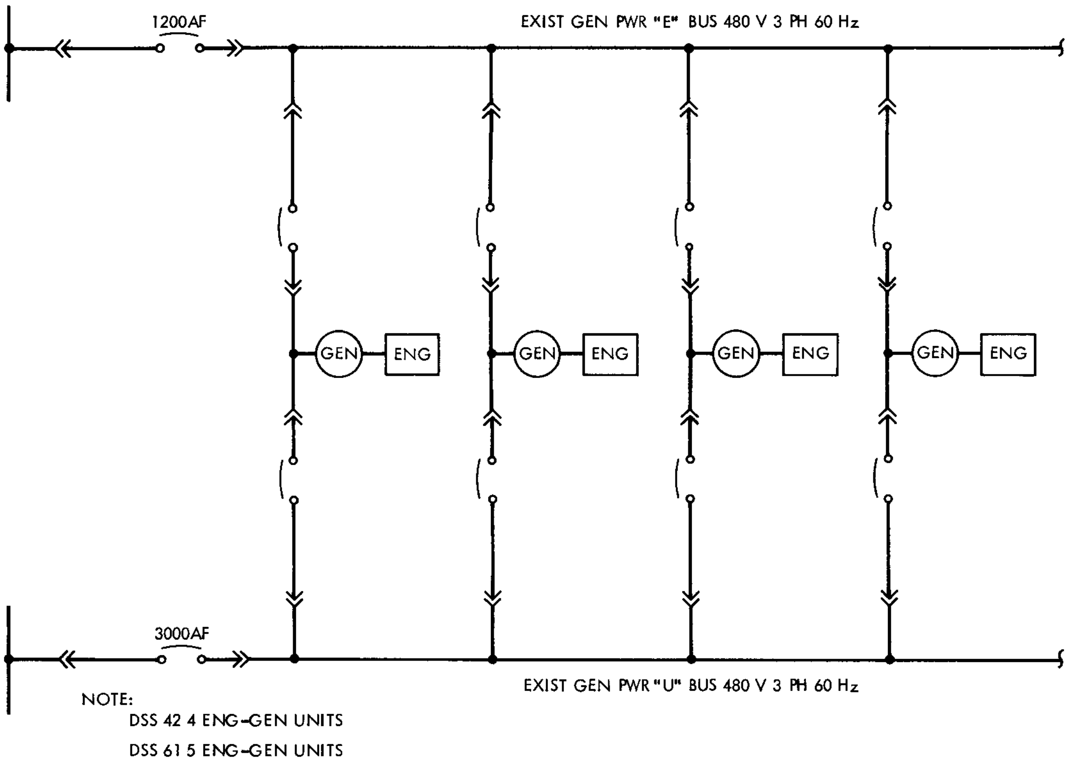


Fig. 1. Single line diagram of 26-m antenna power generation and distribution system

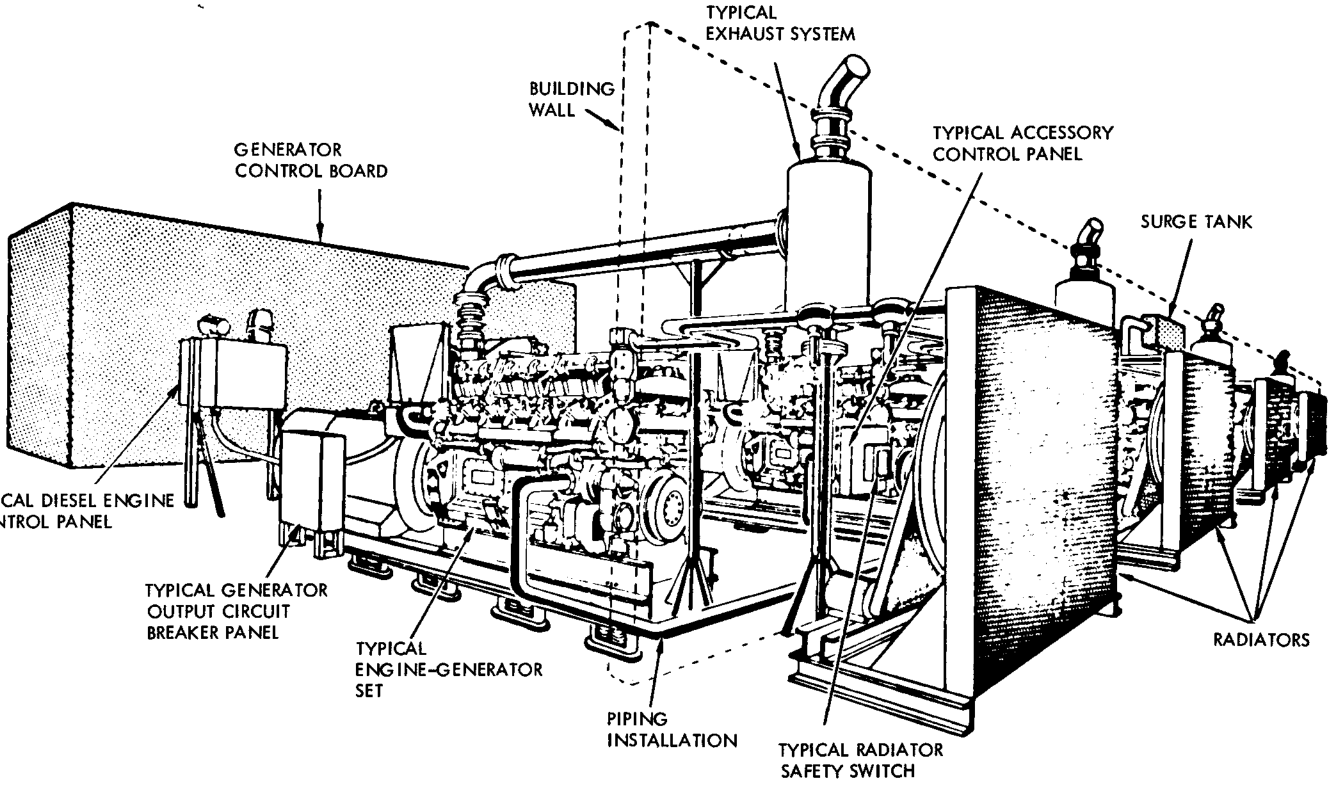


Fig. 2. Typical 26-m antenna engine–generator line-up

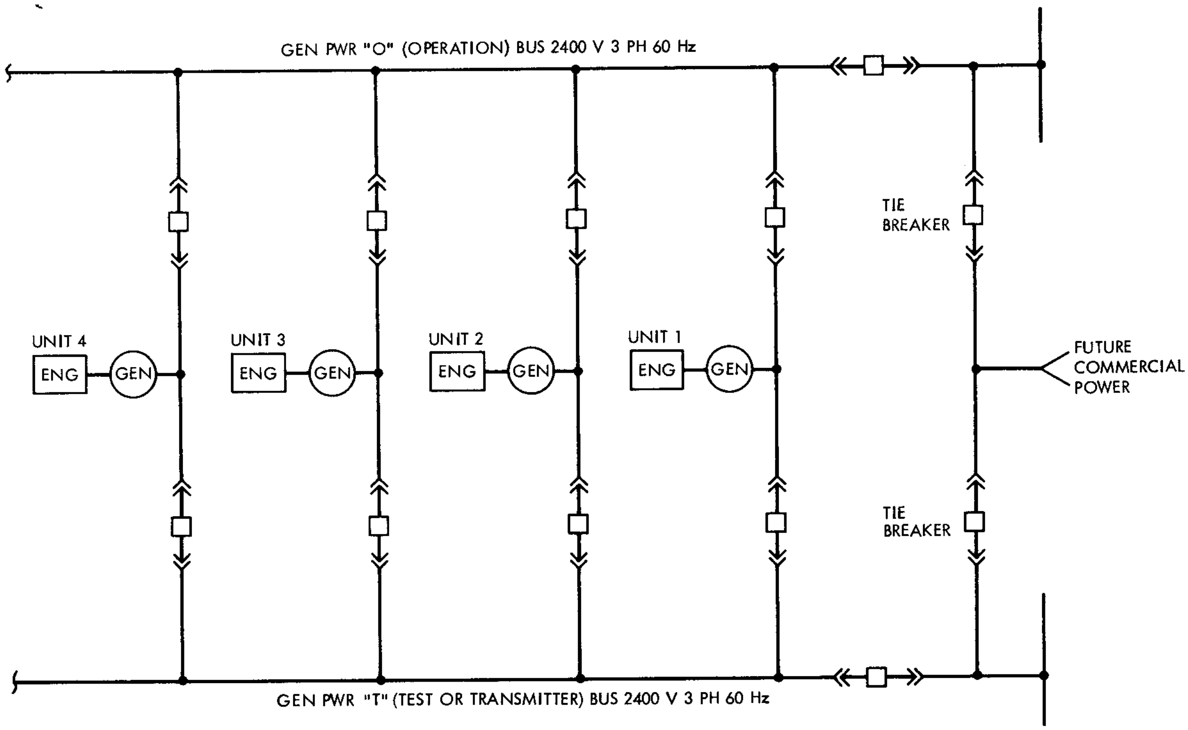
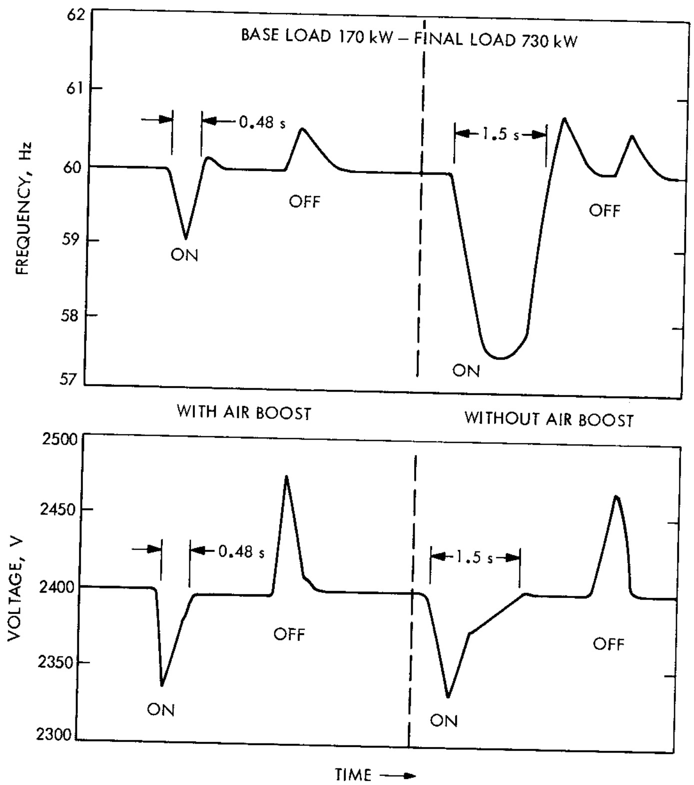


Fig. 3. Single line diagram of 64-m antenna power generation and distribution system



NATIONAL COMMUNICATION SYSTEM REQUIREMENTS:

STEADY-STATE LIMITS – 2280 TO 2520 V, 59.7 TO 60.3 Hz

TRANSIENT LIMITS – 1920 TO 2640 V, 58.02 TO 61.98 Hz
RECOVERY WITHIN 0.5 s

Fig. 4. Voltage and frequency deviations of power systems

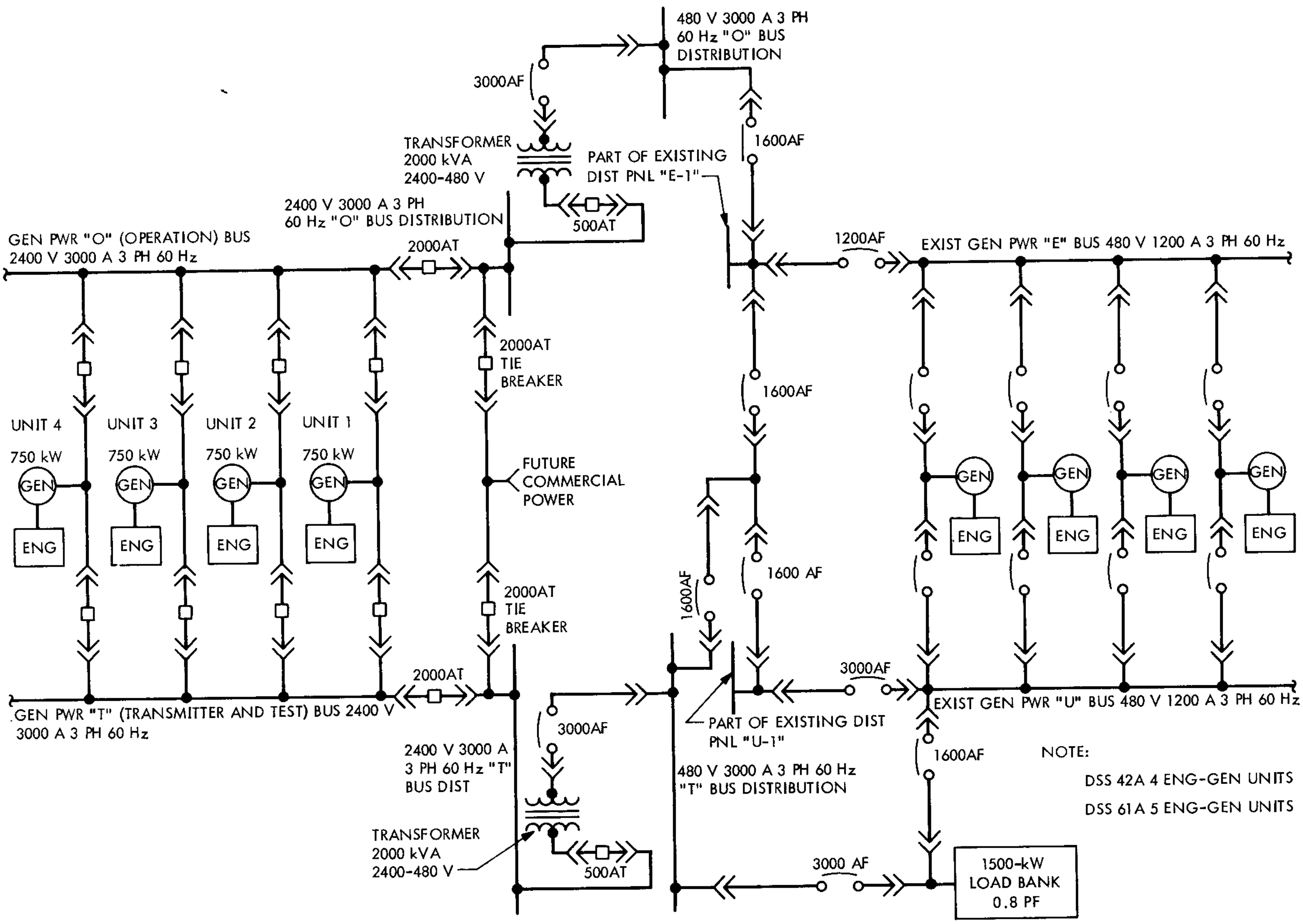


Fig. 5. Single line diagram of integrated 26-m and 64-m antenna power generation and distribution systems